

Massachusetts Avenue – Recommendations

To: Wayne Chouinard, P.E., Town of Arlington
From: Jason S. Sobel, P.E., PTOE, Green International Affiliates, Inc. (Green)
Date: March 14, 2014
Project: Massachusetts Avenue – Schouler Court to Peg Spengler Way

Introduction & Background

On behalf of the Town of Arlington, Green International Affiliates, Inc. (Green) has evaluated the portion of Massachusetts Avenue from Schouler Court / Lockeland Avenue to Water Street / Peg Spengler Way. Green's evaluation focused on vehicular, pedestrian, and bicycle operations and safety. The town's goal for this project is to develop a plan that consists of pavement markings improvements throughout the study area, to obtain recommendations for minor geometric improvements such as curb extensions (aka "bump outs"), and to better accommodate bicycle traffic along the Massachusetts Avenue corridor. Additionally, this study evaluates the three traffic signals within the study area and makes recommendations for improvements, where appropriate. The Town of Arlington's Transportation Advisory Committee (TAC) has recommended improvements at the Massachusetts Avenue / Mill Street / Jason Street intersection, summarized in a TAC report dated May 9, 2013. This study incorporates and re-evaluates the TAC recommendations to verify that the prior recommendations are consistent with the new recommendations for the improvements along the Massachusetts Avenue corridor.

Existing Conditions

The existing roadway width on Massachusetts Avenue within the study area varies between 57 feet and 70 feet, depending on the section of the roadway. The existing pavement markings within the project area are minimal: the only existing longitudinal pavement markings is a double-yellow center line in the middle of roadways. The travel lanes are generally poorly defined, with some portions of Massachusetts Avenue operating as two travel lanes in each direction, and other portions operating as a single travel lane in each direction. The existing vehicle operations depend upon the roadway width within each segment, the traffic volumes, and the existing vehicular constraints within the corridor. On-street parking is generally permitted on both sides of Massachusetts Avenue throughout the study area.

Within the study area, there are three existing traffic signals, at the intersection of Schouler Court / Lockeland Avenue, at the crosswalk across Massachusetts Avenue to the west of Churchill Avenue, and at the intersection of Mill Street / Jason Street. All other intersections and crosswalks within the study area are unsignalized, with side street traffic under STOP sign control.

A locus map of the project study area is provided on Figure 1.

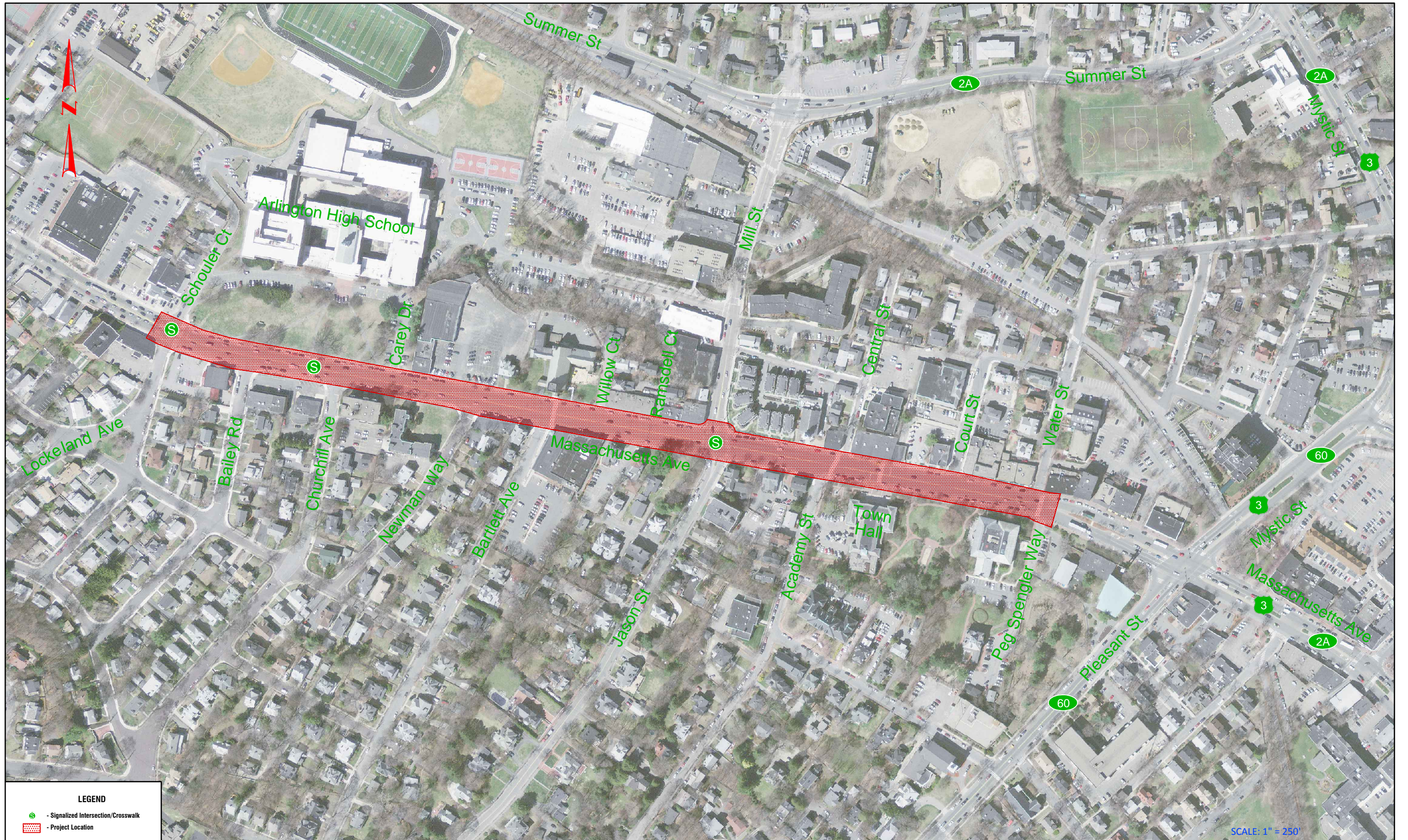


Figure 1

Project Location

Massachusetts Avenue Pavement Marking Recommendations Study
Arlington, Massachusetts

Schouler Court / Lockeland Avenue to Newman Way

Between Schouler Court / Lockeland Avenue and Newman Way, the curb-to-curb width of Massachusetts Avenue varies between 57-58 feet wide. The one exception to this is at the crosswalk to the east of Carey Drive, where curb extensions have been recently constructed and the roadway width is 44 feet. During peak periods, the westbound traffic in this segment typically uses the roadway as two lanes, while the eastbound traffic typically uses the roadway as a single travel lanes. These traffic patterns are a result from the respective upstream roadway widths and lane arrangements.

To the west of Schouler Court, the existing pavement markings on Massachusetts Avenue clearly delineate a single travel lane in each direction. As such, eastbound vehicular traffic entering this segment of Massachusetts Avenue is already traveling in a single lane and generally continues to do so throughout this roadway segment.

The westbound traffic in this segment generally travel in two lanes. This is due to capacity constraints at the Massachusetts Avenue / Mill Street / Jason Street intersection further east of this segment (where capacity limitations encourage two lanes of travel). However, it is noted that neither the existing traffic volumes, nor any vehicular capacity restraints in this segment, dictate a need for two westbound travel lanes. Rather, drivers tend to continue to travel in two lanes until they are forced to merge to single travel lane. This occurs a short distance to the east of the Massachusetts Avenue / Schouler Court / Lockeland Avenue intersection, where Massachusetts Avenue is clearly striped with a single westbound through travel lane and an exclusive left-turn lane.

In addition to the crosswalks at the signalized intersection of Schouler Court / Lockeland Avenue and the signalized mid-block crosswalk west of Churchill Avenue, there is one unsignalized crosswalk across Massachusetts Avenue in this segment, located to the east of Carey Drive.

Newman Way to Academy Street / Central Street

Between Newman Way and Academy Street / Central Street, the curb-to-curb width of Massachusetts Avenue is generally 68 feet wide (approximately). The one exception is at the crosswalk at Bartlett Avenue, where curb extensions have been recently constructed and the roadway width is 56 feet. Vehicular traffic generally uses the roadway as two travel lanes in each direction, though no lane lines are provided.

In addition to the crosswalks at the signalized intersection of Mill Street / Jason Street, there is one unsignalized crosswalk across Massachusetts Avenue in this segment, located at Bartlett Avenue.

Academy Street / Central Street to Water Street / Peg Spengler Way

Between Academy Street / Central Street and Water Street / Peg Spengler Way, the existing curb-to-curb width of Massachusetts Avenue typically varies between 61-62 feet wide. Vehicular traffic generally uses the roadway as two travel lanes in each direction, though no lane lines are provided.

There are three unsignalized crosswalks across Massachusetts Avenue in this segment, located at Academy Street / Central Street, in front of the Arlington Town Hall, and at Water Street / Peg Spengler Way.

Existing Traffic Volumes

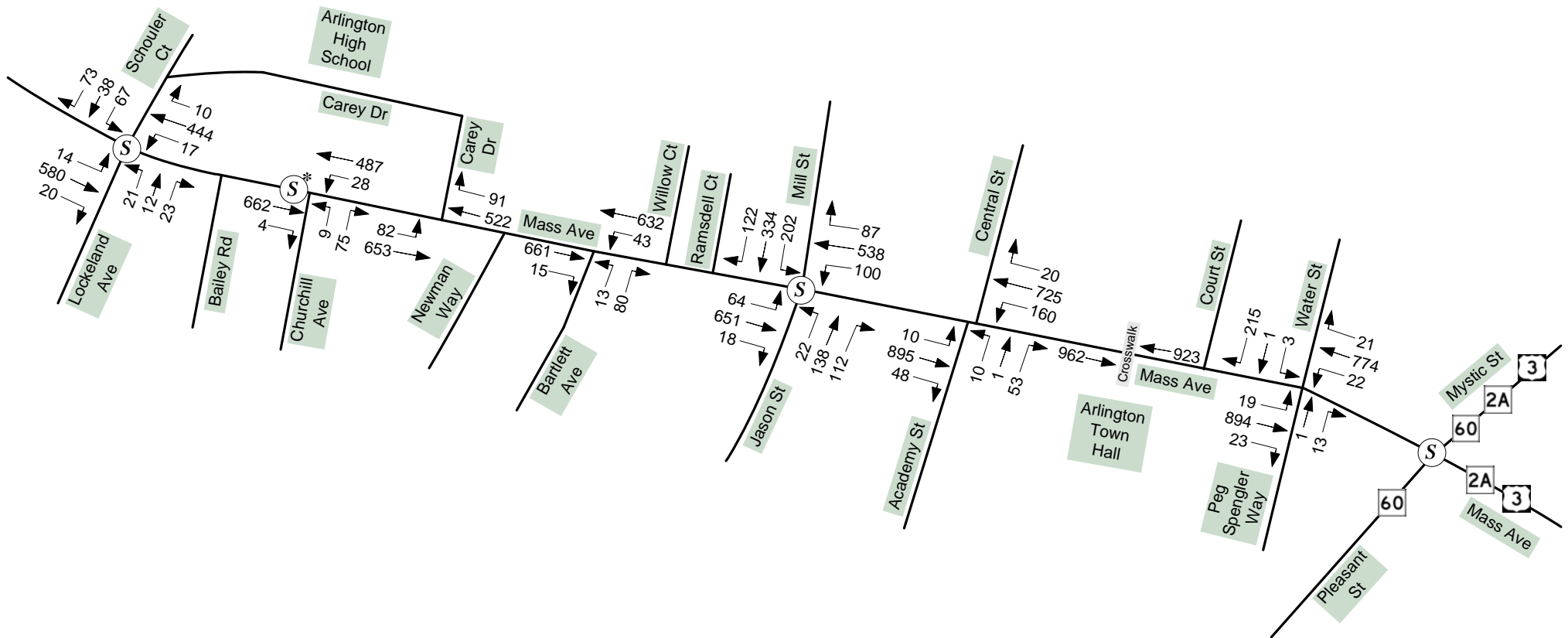
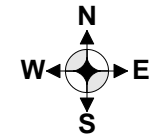
Existing traffic volumes were collected at study intersection during the weekday peak periods, and daily traffic data were collected on Massachusetts Avenue. Manual Turning Movement Counts (TMC's) were collected during the weekday morning and afternoon peak periods. The TMC data were collected Tuesday December 3, 2013 between the hours of 7:00-9:00 AM and 2:00-6:00 PM, and included all vehicular traffic, bicycles, and pedestrians. While the afternoon peak hour occurred during typical commuting times (5:00-6:00 PM at each intersection), it is noted that the peak hour of pedestrian activity occurred much earlier in the day, either between 2:00-3:00 PM, 2:15-3:15 PM, or 2:30-3:30 PM, depending on the exact location. This is likely due the proximity of the Arlington High School, which is located on the north side of Massachusetts Avenue at the west side of the project study area.

The manual TMC's were collected at the following locations:

- Massachusetts Avenue / Schouler Court / Lockeland Avenue
- Massachusetts Avenue / Churchill Avenue / signalized crosswalk across Massachusetts Avenue
- Massachusetts Avenue / Carey Drive (Arlington High School entrance)
- Massachusetts Avenue / Bartlett Avenue
- Massachusetts Avenue / Mill Street / Jason Street
- Massachusetts Avenue / Central Street / Academy Street
- Massachusetts Avenue / crosswalk in front of Town Hall
- Massachusetts Avenue / Water Street / Peg Spengler Way

Figures 2 through 8 summarize the existing peak hour vehicular, pedestrian, and bicycle volumes at each count location. The complete TMC data are contained in the attached appendix.

Proposed Improvements Along Massachusetts Avenue Arlington, Massachusetts



NOT TO SCALE

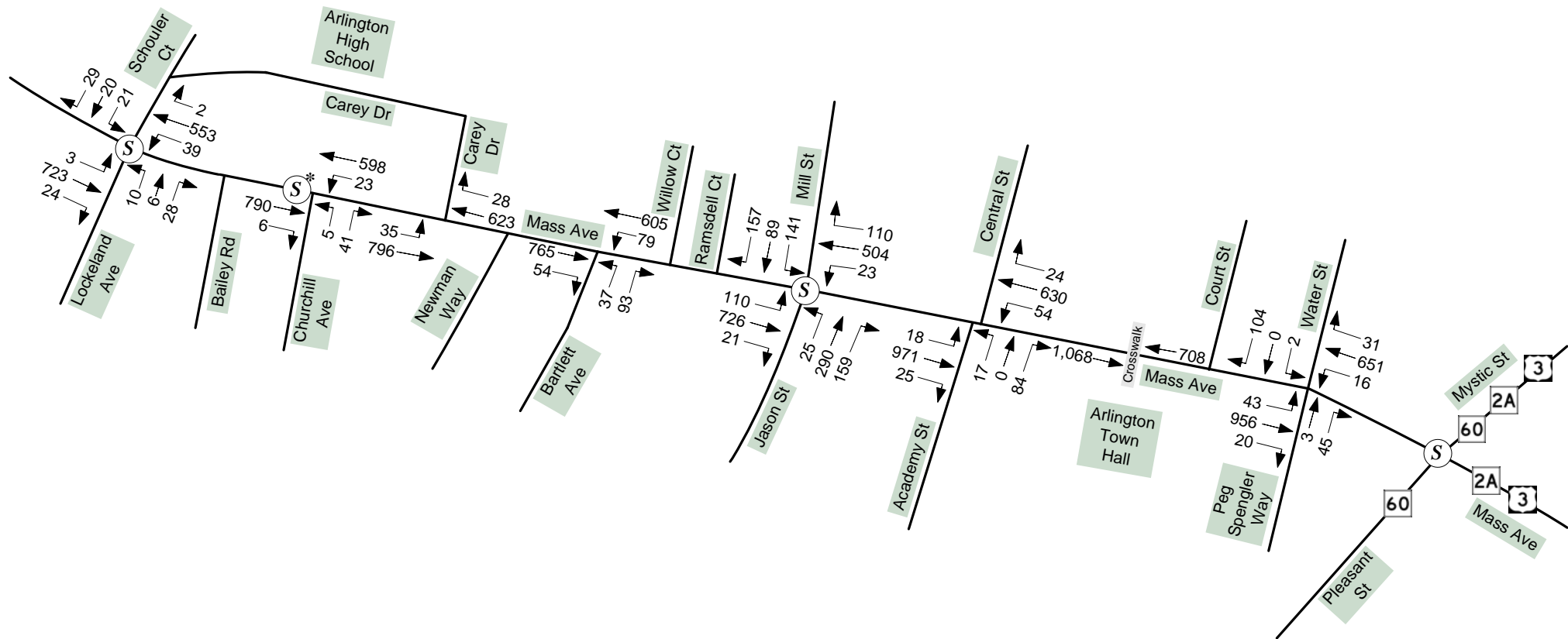
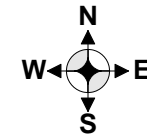
S - Signalized Intersection

S* - Signalized Crosswalk
(Across Mass Ave)

**Existing Weekday Morning Peak
Hour Vehicular Traffic Volumes**

Figure 2

Proposed Improvements Along Massachusetts Avenue Arlington, Massachusetts



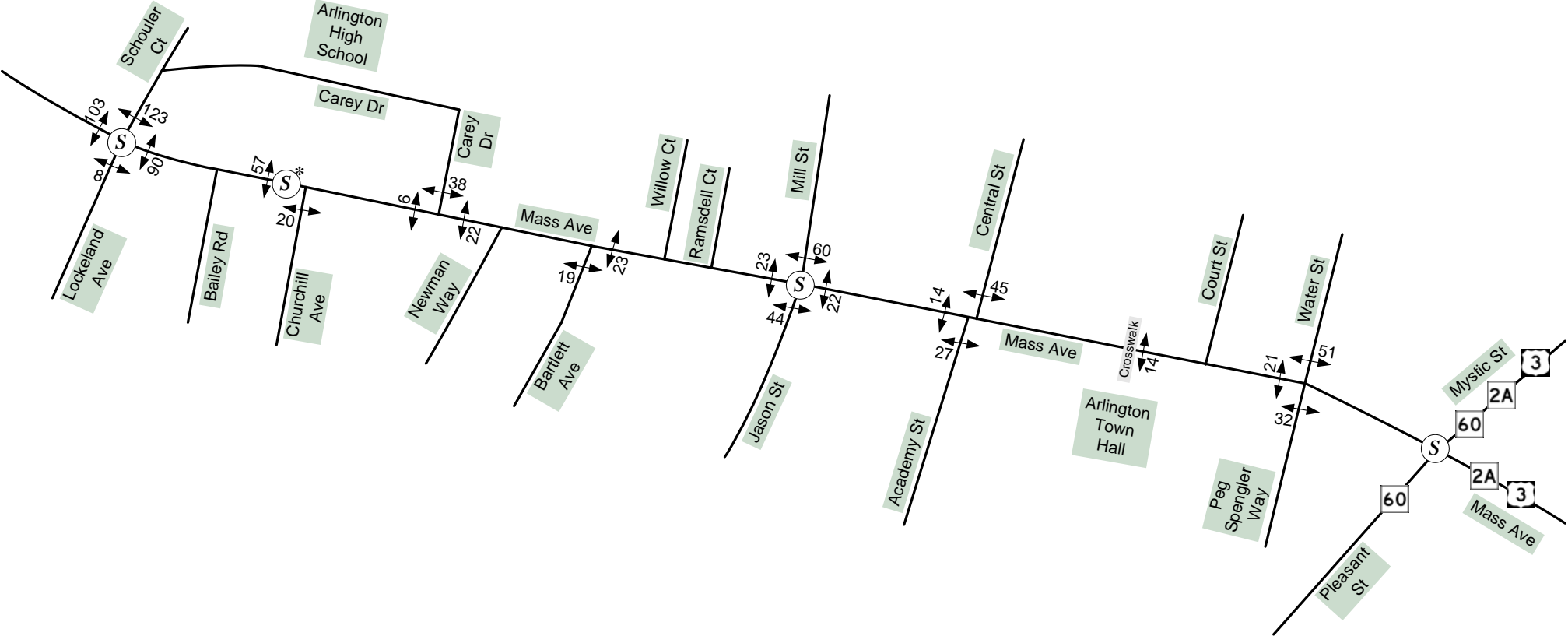
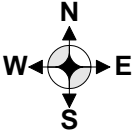
NOT TO SCALE

- S** - Signalized Intersection
- S*** - Signalized Crosswalk (Across Mass Ave)

**Existing Weekday Afternoon Peak
Hour Vehicular Traffic Volumes**

Figure 3

Proposed Improvements Along Massachusetts Avenue Arlington, Massachusetts



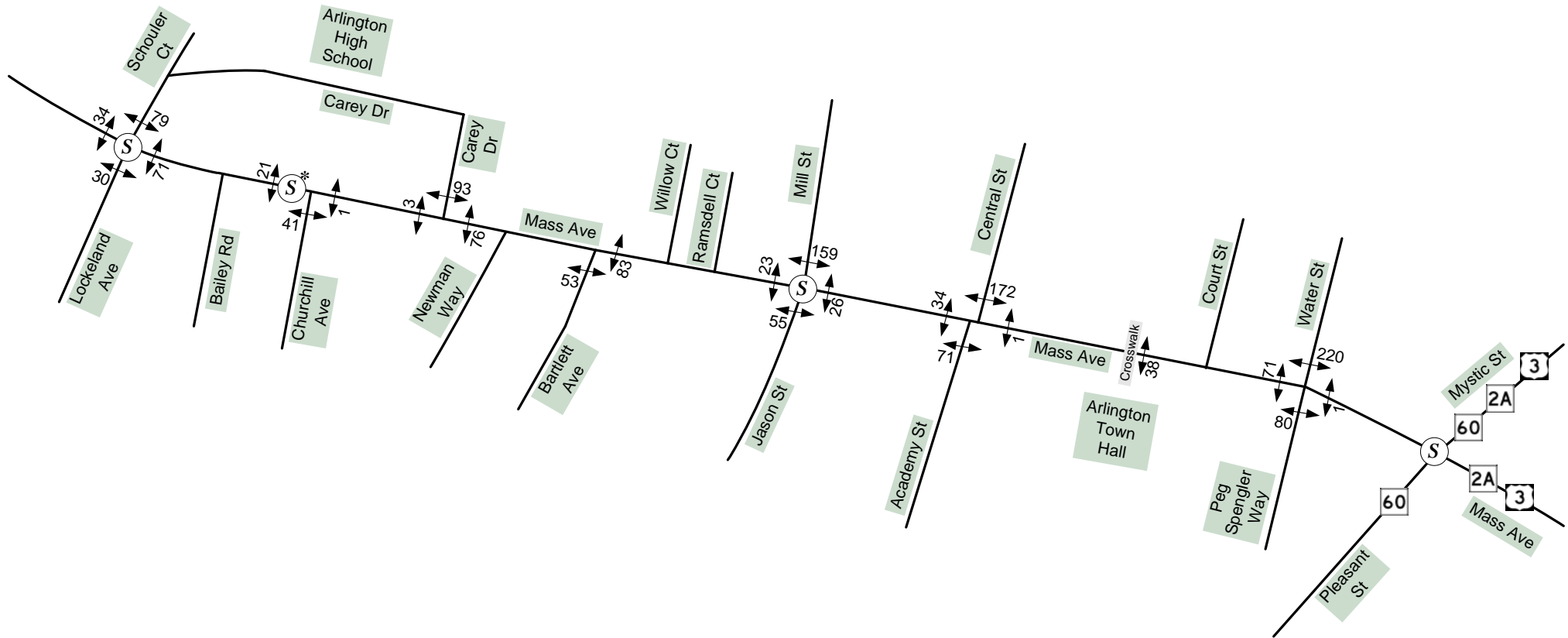
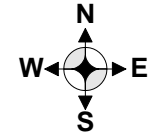
NOT TO SCALE

- (S) - Signalized Intersection
- (S*) - Signalized Crosswalk (Across Mass Ave)

**Existing Weekday Morning
Peak Hour Pedestrian Volumes**

Figure 4

Proposed Improvements Along Massachusetts Avenue Arlington, Massachusetts



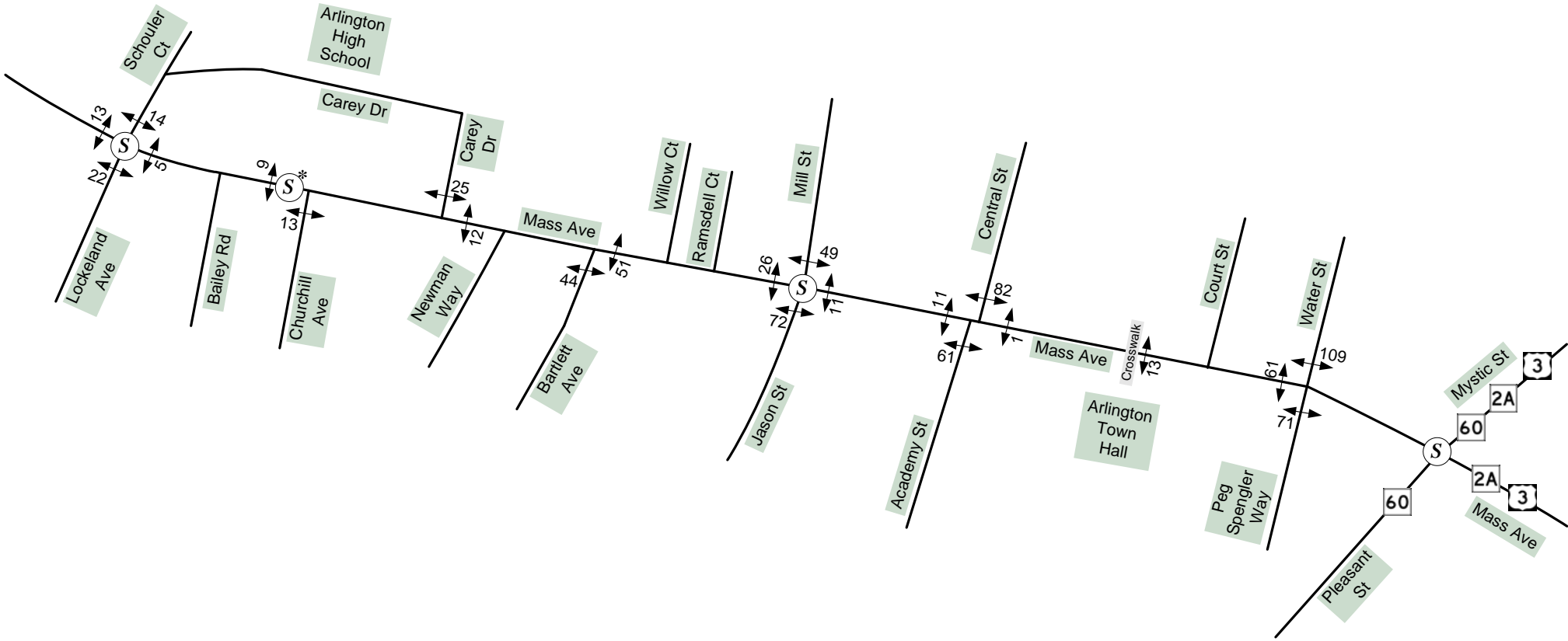
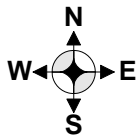
NOT TO SCALE

- Signalized Intersection
- Signalized Crosswalk (Across Mass Ave)

**Existing Weekday Mid-Afternoon
Peak Hour Pedestrian Volumes**

Figure 5

Proposed Improvements Along Massachusetts Avenue Arlington, Massachusetts



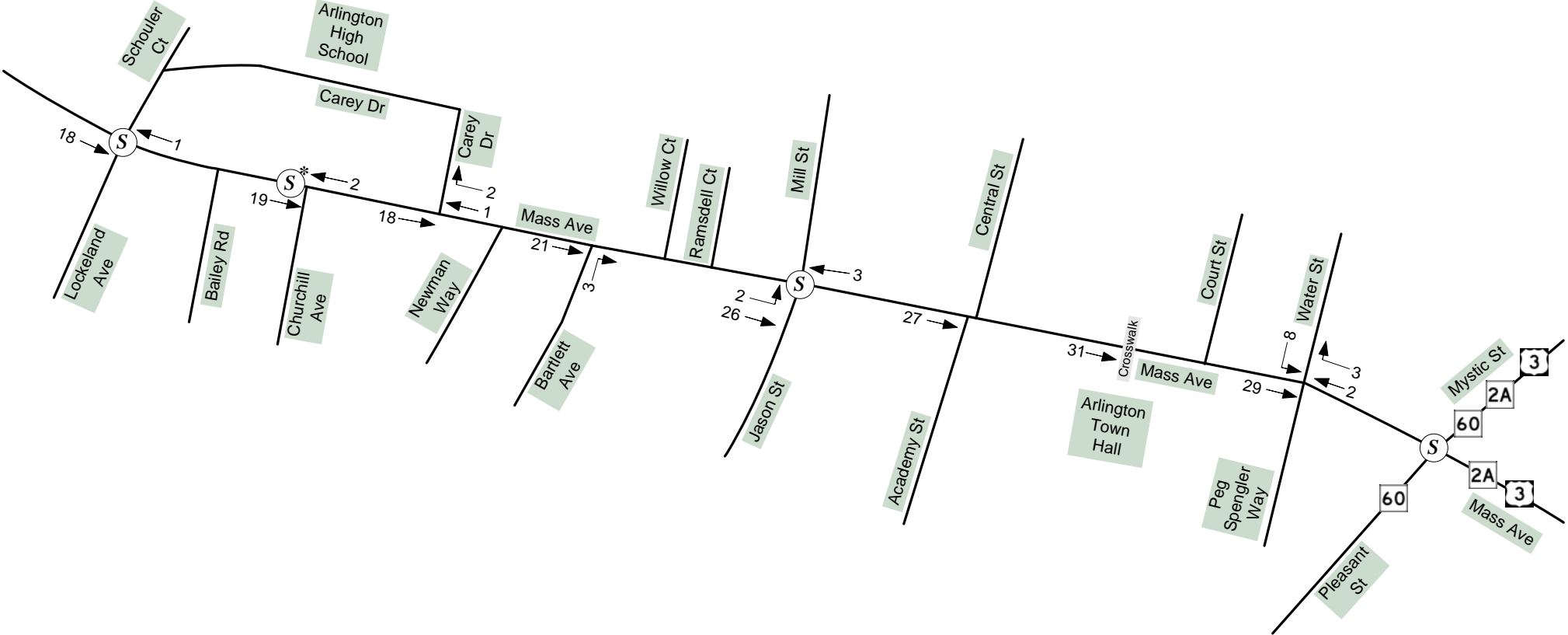
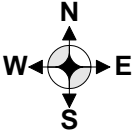
NOT TO SCALE

- (S) - Signalized Intersection
- (S*) - Signalized Crosswalk (Across Mass Ave)

**Existing Weekday Afternoon Vehicular
Peak Hour Pedestrian Volumes**

Figure 6

Proposed Improvements Along Massachusetts Avenue Arlington, Massachusetts



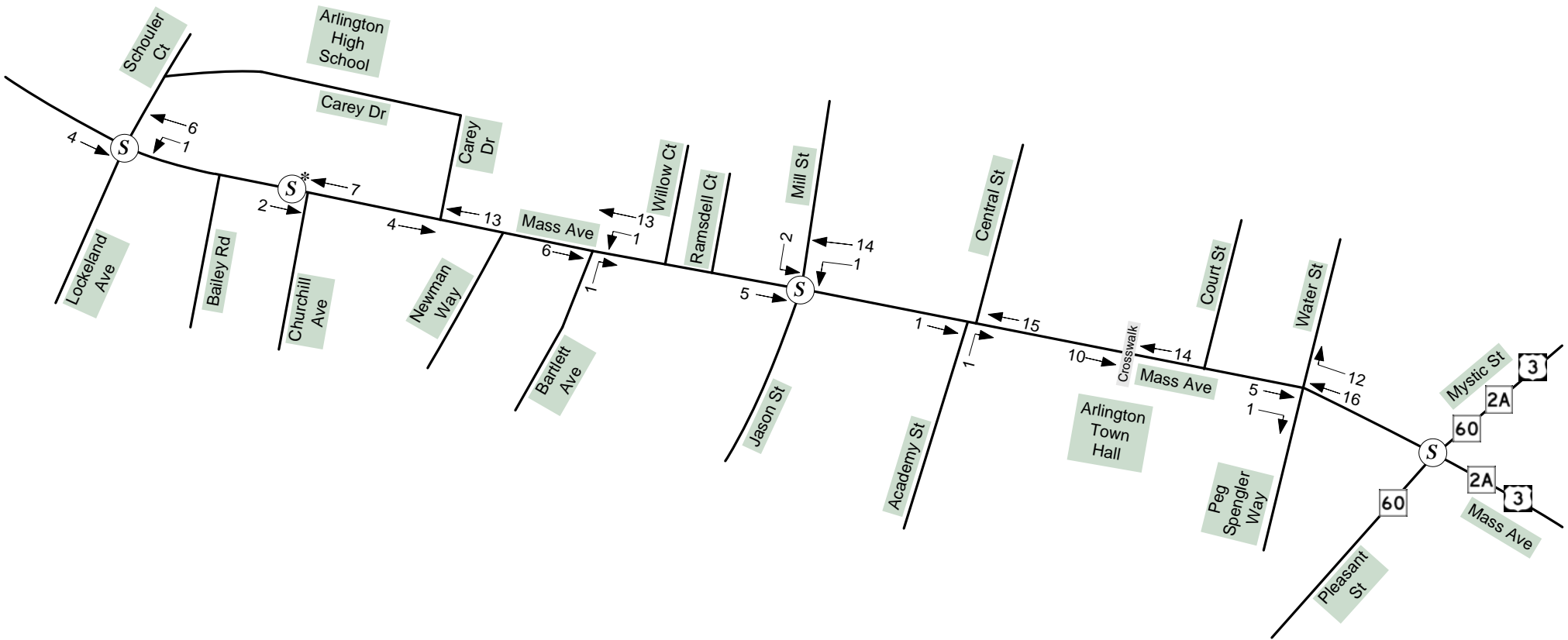
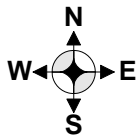
NOT TO SCALE

- (S) - Signalized Intersection
- (S*) - Signalized Crosswalk (Across Mass Ave)

**Existing Weekday Morning
Peak Hour Bicyclist Volumes**

Figure 7

Proposed Improvements Along Massachusetts Avenue Arlington, Massachusetts



NOT TO SCALE

- (S) - Signalized Intersection
- (S*) - Signalized Crosswalk (Across Mass Ave)

*Existing Weekday Afternoon Vehicular
Peak Hour Bicyclist Volumes*

Figure 8

In addition to the peak hour TMC's, daily traffic data were collected on Massachusetts Avenue. Data were collected over a 48-hour period from Tuesday December 3, 2013 through Wednesday December 4, 2013, and included all vehicular traffic volumes, travel speeds, and vehicle classification data. Table 1, below, summarizes the daily traffic volumes data on each roadway. The complete ATR traffic data are contained in the attached appendix.

Table 1: Summary of Daily Traffic Volume Data

| Massachusetts Avenue, east of Bartlett Avenue | | | |
|--|---------------------------------------|---------------------|---------------------|
| | Average Weekday (Tuesday – Wednesday) | | |
| | Daily Average | AM Peak Hour | PM Peak Hour |
| Time Period | Daily | 7:30am – 8:30am | 4:45pm – 5:45pm |
| Traffic Volume ¹ | 17,989 vpd | 1,331 vph | 1,281 vph |
| K-Factor ² | - | 0.074 | 0.071 |
| Directional | 54.5% EB / 45.5% WB | 54.0% EB / 46.0% WB | 58.8% EB / 41.2% WB |
| 85 th Percentile Speed | 33 MPH EB / 31 MPH WB | | |
| ¹ vpd = vehicles per day; vph = vehicles per hour | | | |
| ² K-Factor = Percentage of daily traffic that occurs during the peak hour | | | |

The existing traffic volumes were compared with the most recent seasonal variation data available from MassDOT. The MassDOT data indicate that traffic volumes collected in the month of December are slightly above average. To present a conservative analysis, the existing traffic volumes were *not* adjusted downward to reflect seasonal variations.

Future Conditions – Other Roadway Projects

Improvements at the Massachusetts Avenue / Pleasant Street intersection are currently under design, to be funded by MassDOT's Clean Air and Mobility Program (CLAMP). The limits of work of this project extend along Massachusetts Avenue to Water Street / Peg Spengler Way, at the eastern end of the study area in this report.

The proposed conditions at the eastern Massachusetts Avenue have been considered when evaluating the corridor for this study, and the recommendations contained in this study are consistent with the proposed conditions immediately to the east of the study limits.

Future Conditions – Traffic Volume Projections

Future traffic volumes at the study intersections were projected five years into the future, to the year 2018. The future traffic volume projections consisted of the following components:

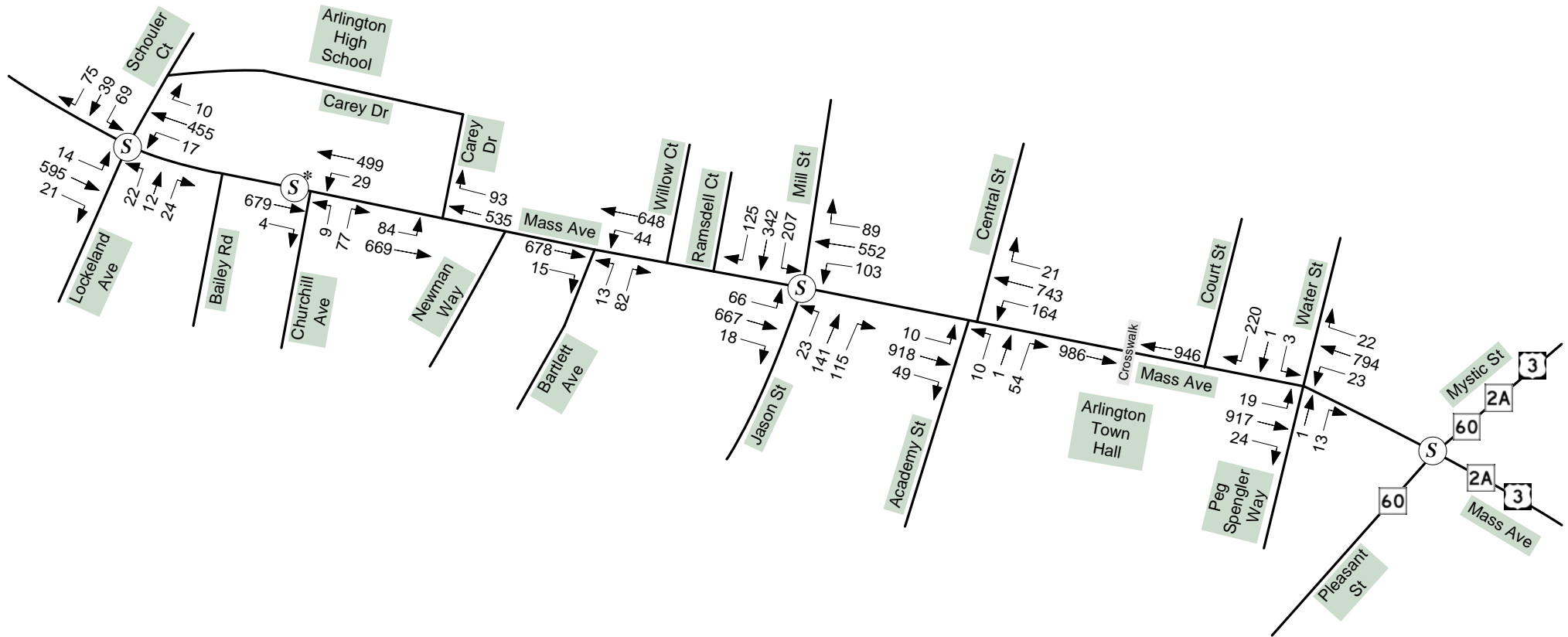
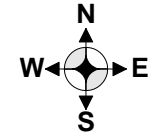
- A general background growth rate;
- Full occupancy assumed for the Arlington 360 project on Summer Street.

Additional trips from the development project at 30-50 Mill Street (the former Brigham's site) were not added to the roadway network, as discussions with the Town of Arlington's Planning and Community Development department indicated that the 30-50 Mill Street project is currently approximately 90% occupied.

A general background growth rate of 0.5% was applied to the existing 2013 traffic volumes to project future traffic conditions. This 0.5% annual background growth rate is consistent with several other traffic studies that have been completed in the area, such as the *Symmes Hospital Redevelopment – Transportation Overview*, prepared by Howard/Stein-Hudson, Inc., September 2004, the *Traffic Impact and Access Study – Proposed Mill Street Residential & Retail Development – 30-50 Mill Street – Arlington, MA*, prepared by MS Transportation Systems/New England Transportation Group, September 2010, and the *Functional Design Report – Bikeway Connection at Massachusetts Avenue, Pleasant Street, and Mystic Street*, prepared by Howard/Stein-Hudson, Inc., November 2012.

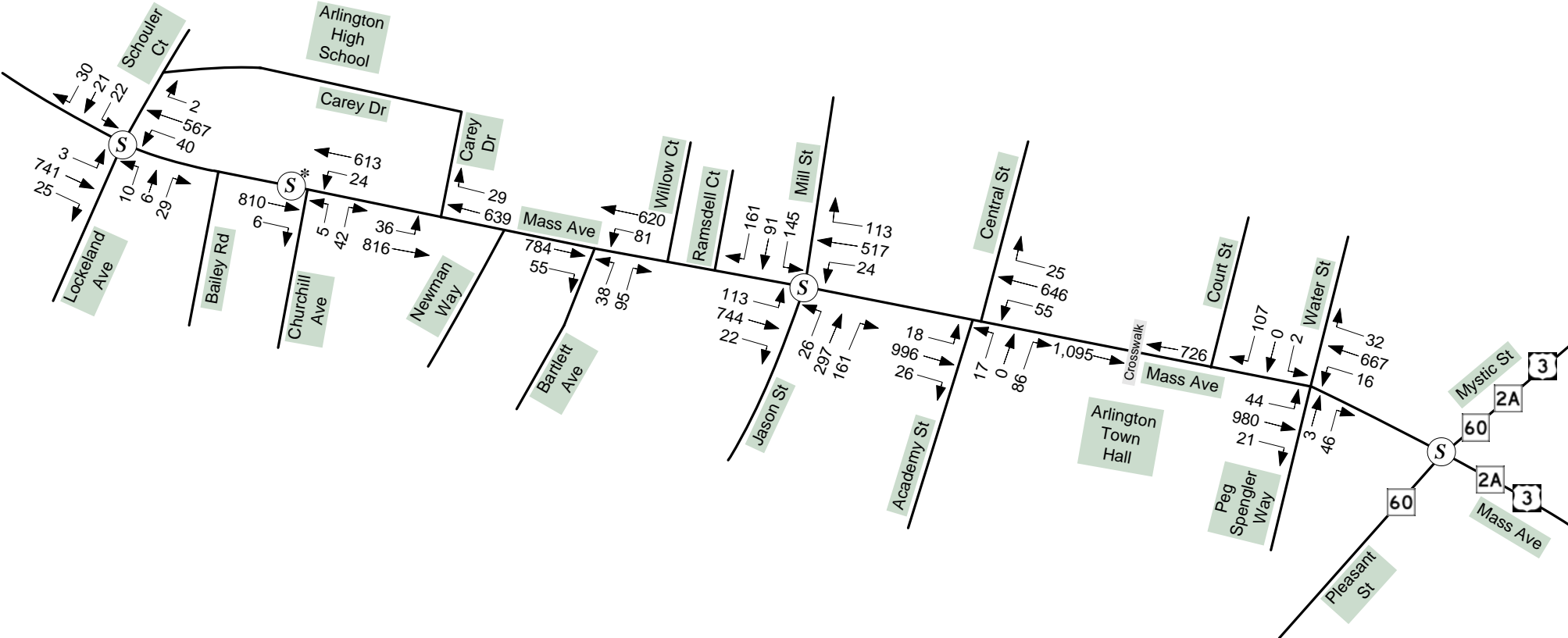
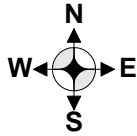
The resulting 2018 future weekday morning and afternoon peak hour traffic volume networks are displayed in Figures 9 and 10.

Proposed Improvements Along Massachusetts Avenue Arlington, Massachusetts



NOT TO SCALE

Proposed Improvements Along Massachusetts Avenue Arlington, Massachusetts



NOT TO SCALE

- (S) - Signalized Intersection
- (S*) - Signalized Crosswalk (Across Mass Ave)

**2018 Weekday Afternoon Peak
Hour Vehicular Traffic Volumes**

Figure 10

Recommended Improvements

The evaluation of the Massachusetts Avenue corridor from Schouler Court / Lockeland Avenue to Water Street / Peg Spengler Way focused on balancing the needs of all users of the roadway, and considered several factors, such as:

- Clearly defined and safe bicycle accommodations;
- Vehicular capacity and maintaining traffic flow;
- Improved pedestrian visibility and safety;
- Consistency along the roadway corridor;
- Matching existing condition to the west of Schouler Court / Lockeland Avenue;
- Matching proposed conditions¹ to the east of Water Street / Peg Spengler Way.

Below is a summary of the proposed roadway striping for each segment of Massachusetts Avenue within the study area. These recommended improvements are shown on Figure 11, a conceptual plan drawn over aerial photography. Additionally, typical roadway cross sections for each segment are shown on Figure 12.

Schouler Court / Lockeland Avenue to Newman Way

In this segment of Massachusetts Avenue, only one through vehicular lane in each direction is required to accommodate the existing and anticipated future traffic volumes. The existing 57-58 ft curb-to-curb width can accommodate 10.5-11 ft through travel lanes in each direction, a 10 ft wide center turning lane (where appropriate), 5 ft wide bicycle lanes, and a 8 ft parking lane on each side of Massachusetts Avenue. The single vehicular travel lane in each direction within this segment is also consistent with the lane configuration immediately to the west of the study area, west of Schouler Court / Lockeland Avenue.

Newman Way to Academy Street / Central Street

The roadway width in this segment of Massachusetts Avenue is approximately 67-68 ft. Two vehicular travel lanes are required in this segment, primarily due to capacity restraints at the Mill Street / Jason Street intersection. With an 8 ft parking lane on each side of the roadway, 5 ft wide bicycle lanes in both direction are not feasible unless some of the vehicular travel lanes were less than 11 ft wide. Based on the traffic conditions in this segment, it is desirable to maintain a minimum of 11 ft wide vehicular lanes, and therefore a bicycle lanes cannot be accommodated in this segment. Instead, 11 ft wide inside travel lanes and 14.5-15 ft wide outside travel lanes are proposed, with shared lane markings (aka “sharrows”) to emphasize the presence of bicycles in the wider right-most travel lanes.

The lane configuration will transition between one through vehicular lane in each direction (to the west of Newmann Way) and two vehicular lanes in each direction between Newman Way and Bartlett Avenue. This distance (approximately 260 ft) is sufficient for two westbound lanes to merge into a single travel lane. Likewise, in the eastbound direction, the lane configuration will transition from a 10.5-11 ft wide travel lane and bicycle lane west of Newman Way, to a 15-15.5 ft wide travel lane and bicycle lane between Newman Way and Bartlett Avenue, to an 11 ft wide left-side vehicular lane and a 14.5-15 ft wide right-side shared travel lane east of Bartlett Avenue.

¹ As shown in the 25% Design Plans “Bikeway Connection at Intersection of Route 3 & Route 60, Massachusetts Avenue, Pleasant Street & Mystic Street”, prepared by Howard/Stein-Hudson Associates, Inc.

Traffic Signal Improvements at the Massachusetts Avenue / Mill Street / Jason Street intersection

At the Mill Street / Jason Street intersection, the recommended lane configuration is consistent with the prior TAC recommendations outlined in their May 9, 2013 report. This lane configuration is still expected to provide the best traffic operations within the existing roadway width.

In addition to the pavement marking improvements along the Massachusetts Avenue corridor, the following improvements are also recommended for the Mill Street / Jason Street intersection:

- Replace existing TS-1 traffic signal controller with a new TS-2 (Type 2) traffic signal controller.
- Replace one signal heads facing eastbound traffic on Massachusetts Avenue with a new four-section signal head. The new four-section signal head will have a bi-modal left-turn arrow that can display both a green arrow and a yellow arrow within a single section of the signal head.
- New pedestrian signal heads with countdown indications to replace existing pedestrian signal heads.
- Audible pedestrian signals will be installed on all corners of the intersection.
- Split phasing for Mill Street and Jason Street will be implemented to eliminate conflicts between these two approaches.
- The exclusive pedestrian phase will be removed and replaced with concurrent pedestrian phasing. The concurrent pedestrian phases will have a 3-5 seconds lead interval, to allow pedestrians to safely enter the crosswalk before vehicles receive a green signal indication.
- Optimized traffic signal timings, based on the proposed signal phasing changes.
- Clearly define the two approach lanes on Mill Street as an exclusive left-turn lane, and a shared through / right-turn lane.
- Reduce the size of the median island on Jason Street to allow for the approach to be striped as two lanes for a short distance. The striping will allow for a shared left-turn / through lane and an exclusive right-turn lane.

These recommendations are consistent with the May 9, 2013 TAC report.

Academy Street / Central Street to Water Street / Peg Spengler Way

With an existing pavement width that varies between 61-62 ft, this segment of Massachusetts Avenue is not wide enough for separate bicycle lanes in either direction. Instead, shared travel lanes, with “sharrow” pavement markings are proposed in both directions. The cross section of this section of Massachusetts Avenue will consist of 8 ft parking lanes on each side of the roadway, 11.5-12 ft wide outside shared travel lanes in each direction, and 11 ft wide inside travel lanes in each direction.

Lastly, the existing crosswalks across Massachusetts Avenue at Academy Street / Central Street and in front of the Arlington Town Hall are approximately 115 ft apart. While it would be preferable to consolidate these crosswalks to a single crosswalk location on the east side of Central Street, it is not currently feasible due to the recently relocated MBTA bus stops, and the Town’s desire to maintain a crosswalk in the vicinity of Town Hall. However, curb extensions are proposed at the crosswalk location in front of Town Hall. This will improve safety and visibility for pedestrians, and reduce the crossing distance.

Improved Pedestrian Signing

To further improve pedestrian safety, the conspicuity of pedestrian warning signs can be enhanced with pedestrian activated flashing yellow warning beacons. These pedestrian activated devices can improve the compliance rates of drivers yielding to pedestrians, and are particularly effective because they are only active when a pedestrian is about to enter, or already within a crosswalk.

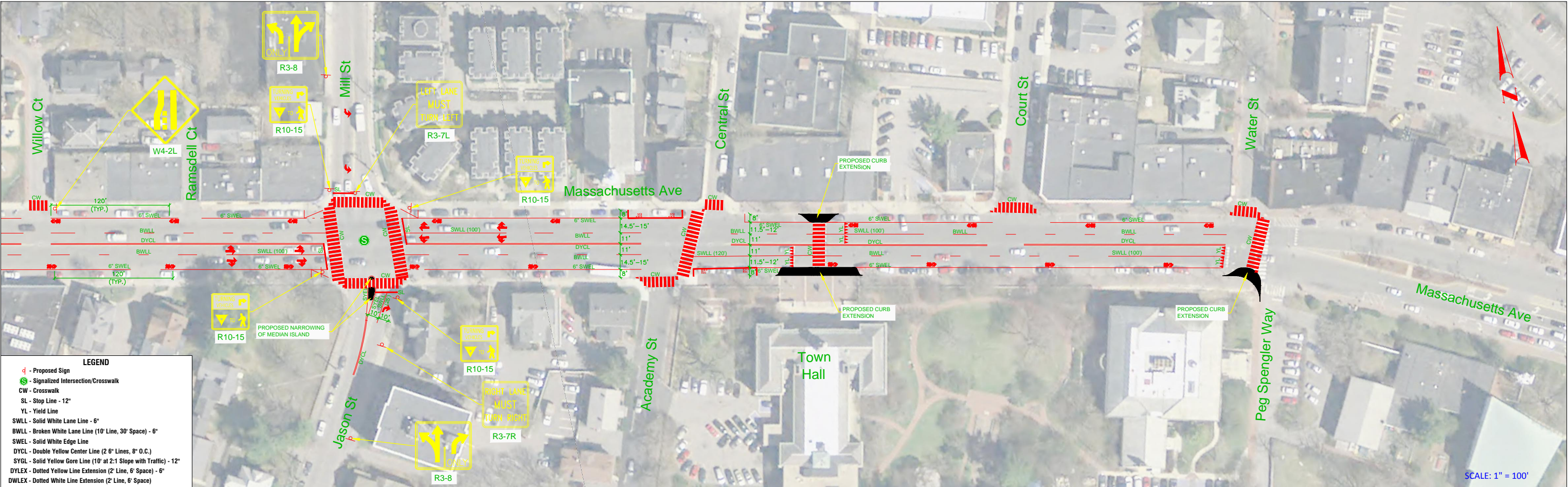
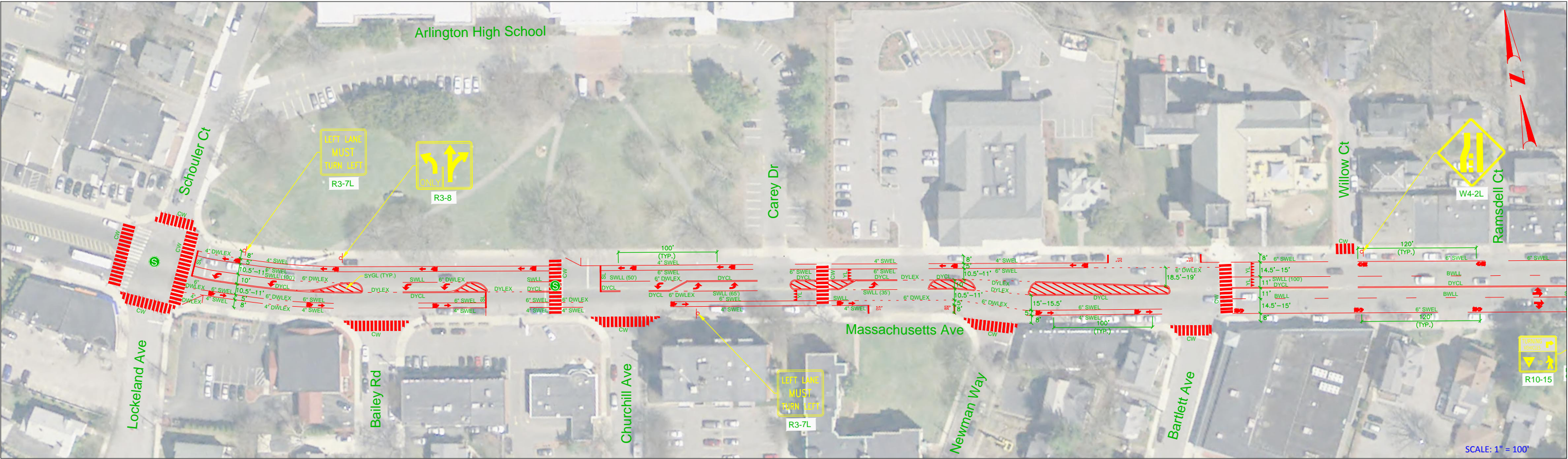
There are no specific warrants or conditions that must be satisfied prior to the installation of pedestrian activated flashing warning beacons. Rather, they can be installed at any location where improved visibility and a greater emphasis on the pedestrian crossing is desired. Along the Massachusetts Avenue corridor, the most appropriate locations for the pedestrian activated flashing warning beacons are as follows:

- Crosswalk east of Carey Drive
- Crosswalk in front of Town Hall



Pedestrian Activated Flashing Yellow Warning Beacons

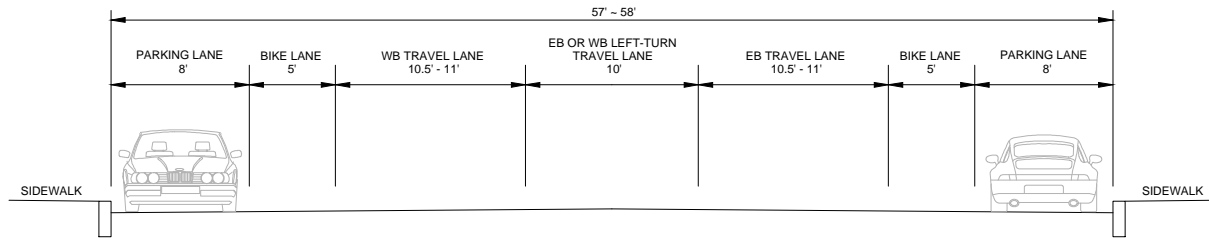
Curb extensions have already been constructed at the crosswalk east of Carey Drive, and they are recommended at the crosswalk in front of Town Hall. At both of these locations, the installation of pedestrian activated flashing warning beacons could be particularly effective because they can be installed on the curb extensions and be more visible to drivers .



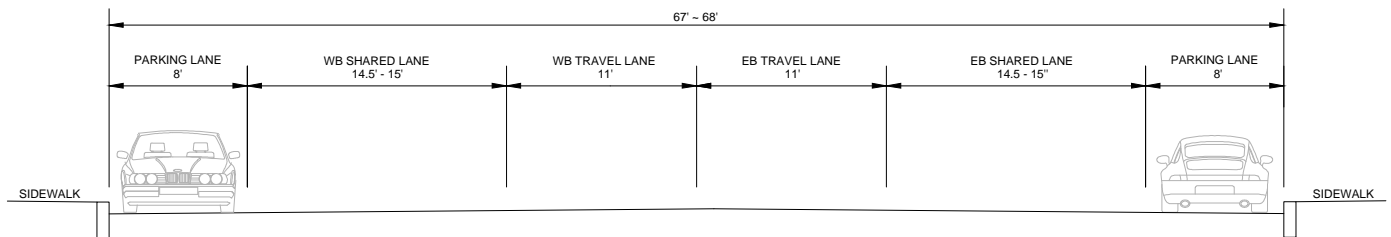
LEGEND

- Proposed Sign
- Signalized Intersection/Crosswalk
- CW - Crosswalk
- SL - Stop Line - 12"
- YL - Yield Line
- SWLL - Solid White Lane Line - 6"
- BWLL - Broken White Lane Line (10' Line, 30' Space) - 6"
- SWEL - Solid White Edge Line
- DYCL - Double Yellow Center Line (2 6" Lines, 8" O.C.)
- SYGL - Solid Yellow Gore Line (10' at 2:1 Slope with Traffic) - 12"
- DYLEX - Dotted Yellow Line Extension (2' Line, 6' Space) - 6"
- DWLEX - Dotted White Line Extension (2' Line, 6' Space)

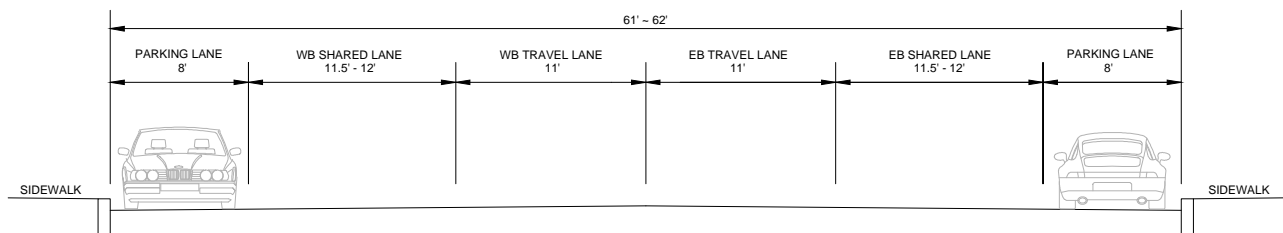
NOTE: CROSSWALK WIDTH: 12' ON MASSACHUSETTS AVENUE, 10' ON ROADWAYS OTHER THAN MASSACHUSETTS AVENUE.



MASSACHUSETTS AVE TYPICAL SECTION A
SCHOULER CT / LOCKELAND AVE - NEWMAN WAY SEGMENT
(LOOKING EAST)



MASSACHUSETTS AVE TYPICAL SECTION B
BARTLETT AVE - ACADEMY ST / CENTRAL ST SEGMENT
(LOOKING EAST)



MASSACHUSETTS AVE TYPICAL SECTION C
ACADEMY ST / CENTRAL ST - WATER ST / PEG SPENGLER WAY SEGMENT
(LOOKING EAST)

NOT TO SCALE



Intersection Capacity Analyses

To assess quality of traffic flow, intersection capacity analyses were conducted for the study intersections for the following three scenarios:

- 2013 Existing Conditions
- 2018 Future No-Build Conditions (Future Traffic Volumes with Existing roadway/intersection conditions)
- 2018 Future Build Conditions (Future Traffic Volumes with recommended improvements)

Within each scenario, analyses were conducted for the weekday morning and afternoon peak hours. The intersection capacity analyses determines vehicular delays, vehicular queuing, and intersection capacity based on the intersection geometry, traffic signal timing and phasing, and vehicular volumes.

“Level of Service” (LOS) is used to denote the different operating conditions for roadways and intersections under various traffic volume loads. LOS designations range from “A” at best with little or no delays to “F” at worst with long delays and forced flow conditions. LOS ratings for an intersection are based upon the average delay per approaching vehicle.

Definitions of LOS at signalized and unsignalized intersections are defined in the 2010 Highway Capacity Manual. The following tables summarize the relationship between Level of Service, and vehicle delay. It is noted that the delay thresholds in the table below correspond with a volume-to-capacity (v/c) ratio of less than 1.0. For any v/c ratio of greater than 1.0, a LOS F is assigned, regardless of the vehicular delay.

Table 2: Level of Service Criteria

| Level of Service | Delay per Vehicle (seconds) | |
|------------------|-----------------------------|----------------------------|
| | Signalized Intersection | Unsignalized Intersections |
| A | ≤ 10 | ≤ 10 |
| B | > 10 – 20 | > 10 – 15 |
| C | > 20 – 35 | > 15 – 25 |
| D | > 35 – 55 | > 25 – 35 |
| E | > 55 – 80 | > 35 – 50 |
| F | > 80 | > 50 |

source: HCM2010: Highway Capacity Manual, published by the Transportation Research Board, 2010

Detailed traffic analysis networks for the weekday morning and afternoon peak hours were developed to perform the capacity analyses, which utilized the Synchro v8 software. This software implements the methodologies of the 2010 Highway Capacity Manual, and is approved for use by MassDOT. A summary of the intersection capacity analysis is shown in Tables 3 and 4. It is noted that the tables below do not include the intersections east of Mill Street / Jason Street. The recommended improvements to the east of Mill Street / Jason Street are expected to improve pedestrian and bicycle safety, but do not change the existing vehicular lane configuration. For these reasons, there are not expected to be any intersection capacity changes in that segment of Massachusetts Avenue. The complete capacity analysis worksheets for the entire corridor are contained in the attached appendix (including the two study intersections to the east of Mill Street / Jason Street).

Table 3: Intersection Capacity Analysis – Weekday Morning Peak Hour

| | 2013 Existing Conditions | | | | | 2018 Future No-Build | | | | | 2018 Future Build | | | | |
|---|--------------------------|--------------------------------|----------|---|--------------------|----------------------|----------|----------|--------------------|--------------------|-------------------|----------|----------|--------------------|--------------------|
| | Delay | LOS | v/c | 50 th Q | 95 th Q | Delay | LOS | v/c | 50 th Q | 95 th Q | Delay | LOS | v/c | 50 th Q | 95 th Q |
| Mass Ave / Schouler Ct / Lockeland Ave | | | | | | | | | | | | | | | |
| Mass Ave EB LTR | 47.6 | D | 0.94 | 356 | 627 | 53.0 | D | 0.96 | 374 | 657 | 44.2 | D | 0.93 | 355 | 552 |
| Mass Ave WB L | 20.1 | C | 0.11 | 7 | 24 | 20.4 | C | 0.12 | 7 | 24 | 16.9 | B | 0.11 | 6 | 20 |
| Mass Ave WB TR | 35.5 | D | 0.73 | 231 | 382 | 38.6 | D | 0.75 | 241 | 429 | 30.7 | C | 0.70 | 226 | 325 |
| Lockeland Ave NB LTR | 21.8 | C | 0.23 | 18 | 49 | 21.4 | C | 0.24 | 18 | 50 | 24.7 | C | 0.30 | 18 | 52 |
| Schouler Ct SB LTR | 39.9 | D | 0.69 | 87 | 150 | 40.0 | D | 0.70 | 90 | 154 | 53.9 | D | 0.81 | 90 | 187 |
| <i>Overall Intersection</i> | <i>40.9</i> | <i>D</i> | <i>-</i> | <i>-</i> | <i>-</i> | <i>44.5</i> | <i>D</i> | <i>-</i> | <i>-</i> | <i>-</i> | <i>39.7</i> | <i>D</i> | <i>-</i> | <i>-</i> | <i>-</i> |
| Mass Ave / Signalized Crosswalk near Churchill Ave | | | | | | | | | | | | | | | |
| Mass Ave EB T | 9.1 | A | 0.54 | 192 | 287 | 9.4 | A | 0.55 | 201 | 300 | 9.1 | A | 0.55 | 201 | 295 |
| Mass Ave WB T | 4.8 | A | 0.22 | 52 | 72 | 4.8 | A | 0.22 | 54 | 74 | 6.7 | A | 0.42 | 126 | 188 |
| <i>Overall Intersection</i> | <i>7.3</i> | <i>A</i> | <i>-</i> | <i>-</i> | <i>-</i> | <i>7.4</i> | <i>A</i> | <i>-</i> | <i>-</i> | <i>-</i> | <i>8.1</i> | <i>A</i> | <i>-</i> | <i>-</i> | <i>-</i> |
| Mass Ave / Churchill Ave | | | | | | | | | | | | | | | |
| Mass Ave WB LT | 0.7 | A | 0.04 | - | 3 | 0.7 | A | 0.04 | - | 3 | 0.5 | A | 0.04 | - | 3 |
| Churchill Ave NB LR | 18.5 | C | 0.27 | - | 28 | 19.2 | C | 0.28 | - | 28 | 20.6 | C | 0.30 | - | 30 |
| Mass Ave / Carey Dr | | | | | | | | | | | | | | | |
| Mass Ave EB LT | 1.1 | A | 0.11 | - | 10 | 1.1 | A | 0.12 | - | 10 | 1.1 | A | 0.12 | - | 10 |
| Mass Ave / Bartlett Ave | | | | | | | | | | | | | | | |
| Mass Ave WB LT | 1.0 | A | 0.06 | - | 5 | 1.0 | A | 0.06 | - | 5 | 1.0 | A | 0.06 | - | 5 |
| Bartlett Ave NB LR | 16.3 | C | 0.25 | - | 25 | 16.8 | C | 0.26 | - | 25 | 21.9 | C | 0.33 | - | 35 |
| Mass Ave / Mill St / Jason St | | | | | | | | | | | | | | | |
| Mass Ave EB LT/TR | 32.9 | C | 0.77 | 224 | 284 | 34.6 | C | 0.80 | 231 | 292 | 37.9 | D | 0.74 | 296 | 360 |
| Mass Ave WB LT/TR | 82.3 | F | 1.04 | 328 | 453 | 96.0 | F | 1.09 | 350 | 475 | 83.4 | F | 1.03 | 452 | 585 |
| Jason St NB LT | 45.9 | D | 0.62 | 109 | 191 | 50.2 | D | 0.68 | 115 | 214 | 80.9 | F | 0.76 | 164 | 251 |
| Jason St NB R | 33.2 | C | 0.30 | 68 | 120 | 33.3 | C | 0.31 | 70 | 123 | 73.1 | E | 0.62 | 113 | 185 |
| Mill St SB L | 54.8 | D | 0.76 | 145 | 269 | 57.8 | E | 0.79 | 151 | 281 | 45.9 | D | 0.44 | 180 | 261 |
| Mill St SB TR | 104.1 | F | 1.08 | 405 | 614 | 112.4 | F | 1.11 | 424 | 632 | 100.1 | F | 1.04 | 540 | 769 |
| <i>Overall Intersection</i> | <i>64.2</i> | <i>E</i> | <i>-</i> | <i>-</i> | <i>-</i> | <i>71.0</i> | <i>E</i> | <i>-</i> | <i>-</i> | <i>-</i> | <i>68.8</i> | <i>E</i> | <i>-</i> | <i>-</i> | <i>-</i> |
| Abbreviations: | | | | | | | | | | | | | | | |
| EB = Eastbound | L = Left | LT = Left and Through | | Delay = Average delay per vehicle (measured in seconds) | | | | | | | | | | | |
| WB = Westbound | T = Through | TR = Through and Right | | LOS = Level of Service | | | | | | | | | | | |
| NB = Northbound | R = Right | LR = Left and Right | | v/c = Volume to capacity ratio | | | | | | | | | | | |
| SB = Southbound | | LTR = Left, Through, and Right | | 50 th Q = 50 th percentile queue length (measured in feet), assumes 25 ft per vehicle | | | | | | | | | | | |
| | | | | 95 th Q = 95 th percentile queue length (measured in feet), assumes 25 ft per vehicle | | | | | | | | | | | |

Table 4: Intersection Capacity Analysis – Weekday Afternoon Peak Hour

| | 2013 Existing Conditions | | | | | 2018 Future No-Build | | | | | 2018 Future Build | | | | |
|---|--------------------------|--------------------------------|------|--------------------|--------------------|---|----------|------|--------------------|--------------------|-------------------|----------|------|--------------------|--------------------|
| | Delay | LOS | v/c | 50 th Q | 95 th Q | Delay | LOS | v/c | 50 th Q | 95 th Q | Delay | LOS | v/c | 50 th Q | 95 th Q |
| Mass Ave / Schouler Ct / Lockeland Ave | | | | | | | | | | | | | | | |
| Mass Ave EB LTR | 24.2 | C | 0.74 | 393 | 677 | 25.3 | C | 0.76 | 428 | 706 | 24.2 | C | 0.75 | 415 | 700 |
| Mass Ave WB L | 15.3 | B | 0.14 | 13 | 36 | 15.6 | B | 0.14 | 13 | 38 | 15.1 | B | 0.14 | 13 | 37 |
| Mass Ave WB TR | 19.4 | B | 0.58 | 249 | 448 | 20.0 | C | 0.60 | 260 | 469 | 18.6 | B | 0.57 | 256 | 409 |
| Lockeland Ave NB LTR | 20.5 | C | 0.23 | 8 | 38 | 20.0 | C | 0.24 | 8 | 39 | 20.7 | C | 0.24 | 8 | 40 |
| Schouler Ct SB LTR | 26.9 | C | 0.38 | 21 | 61 | 27.1 | C | 0.40 | 23 | 63 | 28.1 | C | 0.40 | 24 | 64 |
| <i>Overall Intersection</i> | <i>22.2</i> | <i>C</i> | - | - | - | <i>23.0</i> | <i>C</i> | - | - | - | <i>21.9</i> | <i>C</i> | - | - | - |
| Mass Ave / Signalized Crosswalk near Churchill Ave | | | | | | | | | | | | | | | |
| Mass Ave EB T | 4.4 | A | 0.50 | 0 | 372 | 4.6 | A | 0.51 | 0 | 392 | 4.4 | A | 0.51 | 0 | 387 |
| Mass Ave WB T | 2.0 | A | 0.20 | 0 | 86 | 2.0 | A | 0.21 | 0 | 88 | 3.2 | A | 0.39 | 0 | 237 |
| <i>Overall Intersection</i> | <i>3.4</i> | <i>A</i> | - | - | - | <i>3.5</i> | <i>A</i> | - | - | - | <i>3.9</i> | <i>A</i> | - | - | - |
| Mass Ave / Churchill Ave | | | | | | | | | | | | | | | |
| Mass Ave WB LT | 0.6 | A | 0.03 | - | 3 | 0.6 | A | 0.03 | - | 3 | 0.4 | A | 0.03 | - | 3 |
| Churchill Ave NB LR | 18.5 | C | 0.16 | - | 15 | 19.1 | C | 0.17 | - | 15 | 20.7 | C | 0.18 | - | 15 |
| Mass Ave / Carey Dr | | | | | | | | | | | | | | | |
| Mass Ave EB LT | 0.4 | A | 0.05 | - | 3 | 0.4 | A | 0.05 | - | 3 | 0.4 | A | 0.05 | - | 3 |
| Mass Ave / Bartlett Ave | | | | | | | | | | | | | | | |
| Mass Ave WB LT | 1.9 | A | 0.12 | - | 10 | 2.0 | A | 0.12 | - | 10 | 2.0 | A | 0.12 | - | 10 |
| Bartlett Ave NB LR | 43.0 | E | 0.61 | - | 90 | 49.3 | E | 0.66 | - | 103 | 66.7 | F | 0.76 | - | 125 |
| Mass Ave / Mill St / Jason St | | | | | | | | | | | | | | | |
| Mass Ave EB LT/TR | 49.0 | D | 0.95 | 274 | 406 | 57.3 | E | 0.99 | 284 | 439 | 43.0 | D | 0.86 | 323 | 390 |
| Mass Ave WB LT/TR | 36.8 | D | 0.68 | 229 | 297 | 37.7 | D | 0.70 | 237 | 307 | 52.0 | D | 0.87 | 307 | 372 |
| Jason St NB LT | 48.5 | D | 0.76 | 224 | 336 | 48.8 | D | 0.76 | 231 | 351 | 68.2 | E | 0.86 | 286 | 473 |
| Jason St NB R | 36.1 | D | 0.43 | 101 | 167 | 36.1 | D | 0.43 | 102 | 170 | 49.5 | D | 0.50 | 130 | 217 |
| Mill St SB L | 105.6 | F | 0.97 | 109 | 243 | 109.3 | F | 0.99 | 115 | 252 | 49.3 | D | 0.43 | 117 | 197 |
| Mill St SB TR | 42.4 | D | 0.64 | 167 | 261 | 42.5 | D | 0.64 | 172 | 268 | 73.0 | E | 0.85 | 225 | 394 |
| <i>Overall Intersection</i> | <i>47.5</i> | <i>D</i> | - | - | - | <i>51.0</i> | <i>D</i> | - | - | - | <i>52.8</i> | <i>D</i> | - | - | - |
| Abbreviations: | | | | | | | | | | | | | | | |
| EB = Eastbound | L = Left | LT = Left and Through | | | | Delay = Average delay per vehicle (measured in seconds) | | | | | | | | | |
| WB = Westbound | T = Through | TR = Through and Right | | | | LOS = Level of Service | | | | | | | | | |
| NB = Northbound | R = Right | LR = Left and Right | | | | v/c = Volume to capacity ratio | | | | | | | | | |
| SB = Southbound | | LTR = Left, Through, and Right | | | | 50 th Q = 50 th percentile queue length (measured in feet), assumes 25 ft per vehicle | | | | | | | | | |
| | | | | | | 95 th Q = 95 th percentile queue length (measured in feet), assumes 25 ft per vehicle | | | | | | | | | |

As indicated in Tables 3 and 4, traffic operations along Massachusetts Avenue and on the side streets are expected not expected to change significantly with the recommended improvements in place (including the sections which will have a reduction in vehicular travel lanes).

The most significant changes in vehicle operations will be at the Massachusetts Avenue / Mill Street / Jason Street intersection. At that location, the substantial changes in traffic signal phasing is expected to improve safety by eliminating all conflicts from vehicles on the Mill Street and Jason Street approaches. With respect to intersection capacity, vehicular traffic is expected to operate similarly or better with the recommended improvements.

Conclusion

This study has summarized the evaluation of the Massachusetts Avenue corridor from Schouler Court / Lockeland Avenue to Water Street / Peg Spengler Way, and made recommendations for improvements.

The recommendations contained within this study will provide clarity to vehicular drivers and bicyclists with respect to lane arrangement and configuration, provide safe bicycle accommodations along the corridor, improve pedestrian visibility and safety, and will maintain or improve vehicular operations and traffic flow along Massachusetts Avenue.